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Fuel Cell Demonstration at the U.S. Coast Guard Air Station Cape Cod

Combined heat and power project provides insight into fuel cell-related issues

Overview

The U.S. Coast Guard installed one of the first fuel cells in the New England region, with funding from the Green Power Initiative of the Renewable Energy Trust (administered by the Massachusetts Technology Collaborative), the U.S. Department of Defense's (DOD's) Climate Change Fuel Cell Program, and Key-Span Energy. Beginning in 1998, the Federal Energy Management Program (FEMP) and the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory (CERL) provided technical assistance in the form of project economics, analysis, and site selection.

Energy of Danbury, Connecticut, was responsible for the manufacture, delivery, and installation of the fuel cell.

Fuel cells produce electricity through an electrochemical reaction rather than combustion. While currently more expensive to purchase than conventional power-generating equipment, fuel cells provide efficient, reliable power with minimal emissions. (For more information on fuel cells, see FEMP's Federal Technology Alert, "Natural Gas Fuel Cells"²).

"The R&D Center is considered the pathfinder for new technologies. We're always looking to disrupt the status quo and look for ways to help the Coast Guard do business more efficiently."

—Dr. Steve Allen, U.S. Coast Guard Research and Development Center, Groton, Connecticut



Fuel cell combined heat and power plant located at the U.S. Coast Guard Air Station Cape Cod in Bourne, Massachusetts.

The 250-kW¹ fuel cell combined heat and power plant is located at the U.S. Coast Guard Air Station Cape Cod in Bourne, Massachusetts. The prime contractor, PPL Corporation, was responsible for all engineering and design work. FuelCell

Background

Air Station Cape Cod is one of the largest U.S. Coast Guard air stations on the East Coast, providing support for both fixed-wing aircraft and helicopters for search and rescue, maritime law enforcement operations, and other missions. Its crews protect life and property from the Canadian border to Long Island, New York, and provide logistical support for offshore lighthouses in New England.



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¹ kW = kilowatt.

² www.eere.energy.gov/femp/pdfs/FTA_natgas_fuelcell.pdf

Federal Energy Management Program

Case Study

The U.S. Coast Guard R&D Center wanted to demonstrate that fuel cells were capable of providing power to important operational units during adverse conditions (in the midst of ice storms, blizzards, or other outages). They also wanted a location logistically close to the R&D Center (in Groton, Connecticut), and Air Station Cape Cod proved to be a perfect location.

Fuel cells also have numerous potential benefits, including independence from the electric grid, environmentally friendly power generation, high quality power free from fluctuations and noise, and reliable emergency power. In addition, they can be a cost-effective power supply alternative.

In addition to electric power, the fuel cell provides additional heat for domestic hot water for the bachelor's quarters and an associated galley. The fuel cell currently provides pre-heat for galley dishwashers for the building, and at full 250-kW design output, could also provide space heating for the entire building.



Air Station Cape Cod—the largest Coast Guard station on the East Coast.

Project Summary

The Coast Guard began investigating the use of fuel cells in 1998 based on energy objectives implemented in 1997 that directed the Coast Guard to realize a 20% reduction in facility energy costs from 1995 levels by 2005. The objectives further mandated Coast Guard facilities to “minimize the use of petroleum fuels in all its facilities and platforms ... through investments in engineering.” The U.S. Army Construction Engineering Research Laboratory (CERL) and its subcontractor Science Applications International Corporation (SAIC) investigated

a number of potential locations for a fuel cell at a shore facility, and ultimately Air Station Cape Cod was chosen.

The main benefits of fuel cells used in combined heat and power applications such as this are the relatively low cost electric power and the hot water provided from the waste heat. Fuel cells also provide a major benefit in grid-independent or emergency power source applications, offering an alternative when a site cannot or does not want to be connected to the utility grid.

The fuel cell at Air Station Cape Cod is a Model DFC®300 manufactured by FuelCell Energy. The fuel cell is rated at 250 kW and fueled by natural gas. This installation was one of the first of its kind installed by FuelCell Energy. The complete fuel cell system also includes a heat exchanger to capture waste exhaust heat for use in the galley. An anti-islanding or reverse power relay prevents power from being exported to the grid.

The fuel cell was sized to meet anticipated site loads. For this reason, no attempt was made to provide for exporting power to the grid. This approach provided a lower cost project (as a result of avoidance of additional utility interconnection requirements). However, the result of this decision combined with lower-than-anticipated site loads has led to a situation where the fuel cell must be operated at less than full load to ensure that power is not exported to the grid. To date, the production set point of the fuel cell has been maintained between 150 kW and 180 kW.

The entire project cost to date is \$1.8 million, including all site work and the first year's maintenance costs. The Coast Guard covered approximately 59% of the cost, with 22% paid by the Massachusetts Technology Corporation, 14% by DOE, and the remaining 5% paid for by KeySpan Energy. Subsequent year's maintenance and repair costs are still being negotiated with FuelCell Energy.

The most significant regularly scheduled maintenance item is replacement of the fuel cell stack. The original fuel cell stack is anticipated to last 3 to 5 years, with subsequent stacks lasting 5 to 7 years (as a result of recent technology improvements). The stack replacement cost is estimated to be around \$300,000 to \$350,000. Total maintenance costs will also depend on the level of service chosen by the site, with FuelCell

Federal Energy Management Program

Case Study

Energy offering a variety of plans ranging from minimal coverage and response to complete service and round-the-clock response.

Heat is recovered from the fuel cell via a high-efficiency heat exchanger that is used to heat domestic hot water to 140°F (60°C). The 140°F water serves the galley dishwasher, where it is heated to wash temperature by a supplemental system. The remaining hot water is mixed with make-up water to a temperature of 120°F (49°C) and distributed throughout the barracks. It is believed that once the fuel cell is operating at its full 250-kW design capacity, there will be sufficient heat to provide hot water for the space heating system that serves the facility.

Benefits

In its first 12 months of operation, the fuel cell had an average operating availability of 96.2%—above its first year's expected design availability. The fuel cell produced a total of 1,392 MWh of electricity during the year. Of the total production, 1,250 MWh powered Air Station Cape Cod building loads. The remaining 142 MWh powered the internal fuel cell loads.

Over the same period, an estimated 1,832 million Btus of recovered heat have been utilized for domestic hot water use. This has offset the purchase of nearly 26,300 ccf of natural gas. Total operating expenses for the period were \$146,435, while total system savings were \$170,300, resulting in a total net savings of \$23,865.

The fuel cell at Air Station Cape Cod provided emergency power to the barracks and galley during a number of short grid outages in 2003. A more significant test of its emergency capability was made in September 2003, when the fuel cell was operated in a totally grid-independent mode as a precaution against a potential loss of commercial power during a hurricane. Fortunately, the storm passed to the west of Cape Cod, but the fuel cell operated as designed during the period and proved its worth as an independent power source. Although Cape Cod was not affected by the great utility blackout in the Northeast on August 14–15, 2003, the fuel cell is poised to demonstrate its value in case of a major utility outage.



High-efficiency heat exchanger for domestic hot water production.

Lessons Learned

The most significant lesson learned is that site loads must be accurately determined prior to the design of a fuel cell project. Had the loads been determined more accurately, more buildings could have been connected to the fuel cell or provisions made to export power.

³ MWh = megawatt hours.

⁴ kWh = kilowatt hours.

⁵ Btu = British thermal unit.

⁶ ccf = 100 ft³.



A second lesson learned is that the benefits of a fuel cell system are very dependent on the relative costs of purchased electricity and natural gas. If the cost of natural gas rises more quickly than the cost of purchased electricity (as at Cape Cod Air Station), the economics of a fuel cell change. Although savings are being realized, they are not as large as originally expected. It is possible that in the future, natural gas prices may rise such that it is more economical for the site to purchase electrical power than generate it.

A third lesson learned is that fuel cell maintenance costs (restacking and preventative maintenance) can be significant. While the first year's maintenance was included in the original procurement for this fuel cell, negotiations are still under way between the Coast Guard and FuelCell Energy over future maintenance costs. Long-term maintenance costs should be considered and negotiated prior to procurement of a fuel cell.

Looking Ahead

The most significant barrier to a more successful operation of the Air Station Cape Cod fuel cell is the inability to operate at full power. The fuel cell power generation is limited because the excess power cannot be exported to the grid. The Coast Guard has just received funding for the design and installation of the utility interconnection needed to overcome this barrier. Coast Guard personnel are also working with their utility to reach agreement on export of excess energy. Air Station Cape Cod has recently procured and installed a Btu meter, which will facilitate quantifying the savings associated with waste heat recovery.

For those interested in periodic updates on this fuel cell, monthly reports on the status of the fuel cell and production statistics, see the two URLs below.^{7,8}

Air Station Cape Cod fuel cell demonstration wins 2004 Energy Security and Reliability Award (Small Group)

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Congratulations to

Steve Allen
Jim Christo
Dave Cleveland
LCDR Chris Lund
LCDR Mike Walz

... In the six remaining months of FY 2003, the fuel cell provided approximately 60 percent of the Air Station's demand, saving about \$30,000 in energy costs and more than 2 billion Btu in deferred natural gas purchases. In the case of a catastrophic grid failure, the system is currently capable of providing almost 100 percent of base requirements when operated at full capacity. Additional benefits include reduced emissions, thermal pollution, and noise. This successful project has served as a benchmark for future public and private investments in fuel cell technology.

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Produced for the U.S. Department of Energy, Energy Efficiency and Renewable Energy, by the Pacific Northwest National Laboratory

PNNL-SA-42044

August 2004

⁷ www.uscg.mil/systems/gse/energy/FuelCell/Fuel-Cell-Consolidate-Status-Report-2003.pdf

⁸ www.uscg.mil/systems/gse/energy/FuelCell/Fuel-Cell-Consolidate-Status-Report-2004.pdf